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BNL-94804-2011-AB

OBSERVATIONAL CONSTRAINTS ON CONCENTRATION AND PRODUCTION OF SEA-SPRAY AEROSOL

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For presentation at
The Second Science Team Meeting of the
Atmospheric System Research (ASR) Program,
San Antonio, TX
March 28-April 1, 2011

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U.S. Department of Energy
Office of Science

ABSTRACT

Quantification of the production flux of sea-spray aerosol (SSA) is essential to understanding aerosol, cloud, and radiation processes in the marine atmosphere. SSA is a major and often dominant component of marine aerosol mass; the relative contribution of SSA to aerosol number is much more variable, and present estimates of production flux vary by more than two orders of magnitude (Fig. 1). SSA number, area, and mass concentration can be constrained by measurements; together with estimates of removal rates, such measurements may also provide constraints on production fluxes. For instance, filter measurements of total sodium concentration (a conservative proxy for SSA) typically yield SSA mass concentrations of 10 to 50 μg/m^3; such mass concentrations in turn provide an upper bound on the number concentrations of SSA particles with $r80$ (radius at 80% relative humidity RH, a commonly used measure of SSA particle size) greater than 1 μm of 10 to 50/cm^3, respectively, and of particles with $r80 > 3$ μm, 0.3 to 1.5/cm^3. Similarly, as particles that provide the dominant contribution to extinction of visible radiation are sufficiently large that their extinction efficiency is near 2, measurements of aerosol optical thickness (AOT) provide a constraint on the column burden of the concentration of aerosol surface area. Measured AOT in the marine atmosphere relatively free of anthropogenic influences, which however includes contributions from stratospheric aerosols and tropospheric aerosols other than SSA, is typically 0.05 to 0.1. For typical marine boundary layer height of 0.5 km with uniform RH 80%, the upper bound on the column-average number concentration of SSA particles with $r80 > 1$ μm would thus be 15 to 30/cm^3, and for particles with $r80 > 3$ μm, 2 to 3/cm^3; the expected increase in RH with increasing height would decrease these upper bounds, as would a greater MBL height. Measurements of total aerosol number concentration, which is dominated by smaller particles which similarly include particles other than SSA, provide an upper bound on the number concentration of SSA particles. Total aerosol number concentrations reported under conditions of minimal continental and anthropogenic perturbation range from 200 to 500/cm^3. Such measurements, together with estimated removal rates also bound SSA particle production flux. The dominant factor in determining the lifetimes of particles in the size range 0.01 μm < $r80$ < 3 μm, removal by precipitation, results in particle lifetime given by the time between precipitation events, typically ~3 days, nearly independent of size for particles in this size range. Such a lifetime yields an upper bound estimate on the SSA number production flux. For marine boundary layer height 0.5 km, this upper bound would be 4 to 10 ´ 10^5/m^2/s, near the low end of current estimates of SSA production flux but two orders of magnitude less than other current estimates (Fig. 1).

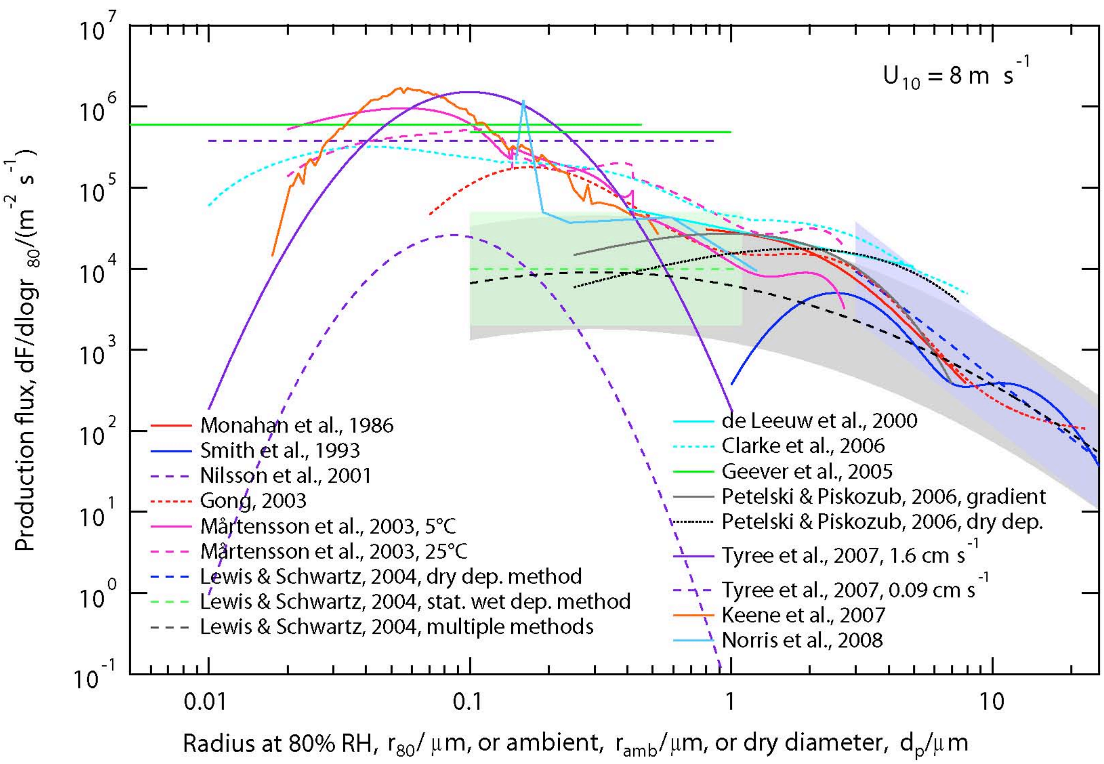

Fig. 1. Estimates of the size-dependent SSA production flux as a function of radius at 80% RH, r80, at wind speed at 10 m above the sea surface U10= 8 m/s, from de Leeuw et al, "Production flux of sea-spray aerosol," *Reviews of Geophysics*, accepted, 2010.